CEBAF EXPERIMENT 91-023

Measurement of Polarized Structure Functions in Inelastic Electron Proton Scattering using CLAS

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This experiment aims at a study of the spin-structure of the proton in the nucleon resonance region from low to moderately high values of Q^2. The EMC measurement of the polarized structure function $g_1(X)$ in the deep inelastic regime suggests that the integral over the difference of the helicity 1/2 and 3/2 total cross section behaves like:

$$\int_{\upsilon_{thr}}^{\infty} \frac{d\upsilon}{\upsilon}(\sigma_{1/2}^{p}(\upsilon,Q^2) - \sigma_{3/2}^{p}(\upsilon,Q^2)) \cong \frac{C}{Q^2}; C > 0$$

If one assumes that the proton spin is carried by valence *u* and *d* quarks only, the resulting value of C is in disagreement with the theoretical expectation from the Ellis-Jaffe sum rule, which is expected to be valid in the deep inelastic regime. This discrepancy has led to the conclusion that in the deep inelastic region the spin of the proton is only partially carried by the quarks. On the other hand, the Gerasimov-Drell-Hearn sum rule for real photons gives a large negative value which is related to the anomalous magnetic moment of the proton.

$$\int_{\upsilon_{thr}}^{\infty} \frac{d\upsilon}{\upsilon}(\sigma_{1/2}^{p}(\upsilon) - \sigma_{3/2}^{p}(\upsilon)) = -\frac{2\pi^2\alpha}{M^2}\kappa^2$$

Obviously, agreement with the GDH sum rule requires dramatic changes in the spin structure when going from the deep inelastic high Q^2 region to the photon point. It is important to study how the spin structure changes with Q^2, for this information is of relevance in determining the fraction of proton spin carried by the quarks in the non-perturbative and transition regimes A recent study showed that nucleon resonance excitations dominate not only the GDH sum rule at the photon point, but are also consistent with a zero crossing of the GDH integral at modestly small Q^2. This indicates that non-perturbative effects play an important role in the interpretation of the polarized structure function measurement performed at Q^2 larger than 1 (GeV)^2.

Determination of the Q^2 dependence of GDH sum rule requires measurement of the helicity asymmetry:

$$A_1 = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}}$$

over a large range of υ and Q^2 using scattering of polarized electrons off polarized protons $\vec{e} + \vec{p} \rightarrow e + X$. The inclusive cross section for this process is given by:

$$\frac{d\sigma}{d\Omega dE'} = \Gamma_T\left\{\sigma_T + \sigma_L \pm \sqrt{1-\varepsilon^2}\cos\psi\sigma_T A_1 \pm \sqrt{2\varepsilon(1-\varepsilon)}\sin\psi\sigma_T A_2\right\}$$

Where A_2 is a transverse-longitudinal interference term, the sign $\pm$ is related to the relative sign of the product of beam and target polarization. The CLAS experiment allows to separate A_1, A_2 in a kinematical region $Q^2 \cong 0.2$ - 2.0 (GeV/c)^2, $W \leq 1.8$ - 2.2 GeV, with high accuracy. The results will be important for understanding the spin structure of the proton in the non-perturbative and transition regime of QCD